Concrete Scanning with GPR

METHOD STATEMENT

MHS PROJECT
MANAGEMENT SERVICE

PROTECTING THE BUILT WORLD

Table of Contents

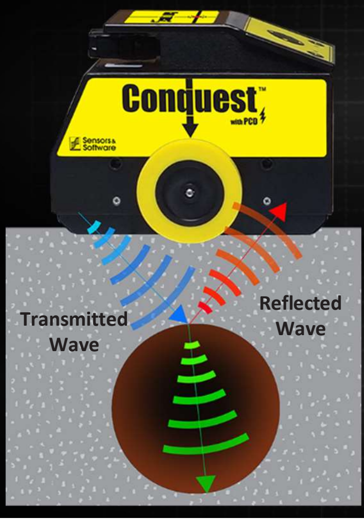
Introduction

When evaluating structural integrity or carrying out retrofits in concrete structures, it is important that you detect embedded objects before digging or drilling. Surveyors around the world use MHS GPR to avoid damage by locating embedded objects before cutting and coring concrete.

This guide is designed to help you become a more skilled GPR operator and, in turn, increase the level of service you provide to your customers by adding to what you learned in the MHS User's Guide and MHS training course. The focus of this guide is to present the bestpractices of data interpretation through case studies to illustrate key points while providing some basic theory.

Following the guidelines suggested here and adhering to good scanning practices will help you minimize accidents and costly "hit" damages. In turn, you will deliver greater satisfaction to your customers.

Basic GPR Theory



A Ground Penetrating Radar (GPR) system consists of a transmitter, a receiver, and a computer for data acquisition and control.

TRANSMIT

The transmitter sends a radio wave into the ground while the receiver listens for returning reflections.

REFLECT

Reflections occur when the radio wave hits a material (metal, for example) that is different from the host material (soil, for example). Some of the wave is reflected back and some travels deeper into the subsurface.

DETECT

The GPR receiver detects and measures this reflected wave. When objects are not detected, it is because not enough radar wave energy was returned to the receiver.

Learning how and what GPR can and cannot do will help you to better assess whether GPR will work on a job site, which will, in turn, help you provide better service to your customers. Uninformed GPR users may oversell GPR's capabilities, negatively affecting everyone involved.

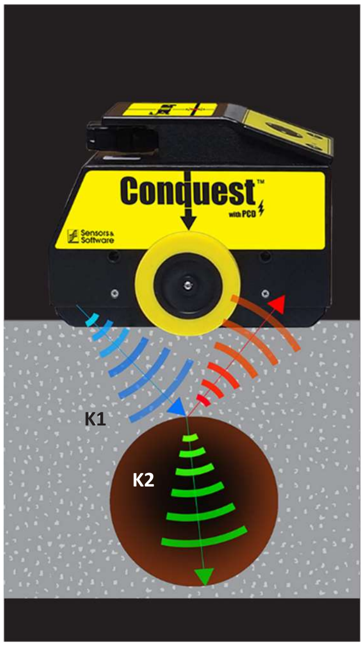
Penetration / Detectability

The usual maximum penetration depth in concrete is about 24" or 600mm. However, you may not always achieve maximum penetration. The following is a list of some of the factors that affect radar penetration and target detection:

- **Material:** The material the GPR wave travels through - concrete, asphalt, gravel, dirt - absorbs the GPR wave; this is referred to as "attenuation". Even when you concentrate on only one material, concrete for example, there are variations between different pours (admixtures, water/cement ratio, air bubbles, aggregate size, etc.) This explains why you can see deeper in some concrete than others. Technically, it is the electrical conductivity of the material that attenuates GPR waves. Water is the biggest contributor to electrical conductivity. Generally, the wetter the concrete, the higher its electrical conductivity, and the worse your penetration will be.
- **Target Composition:** When a GPR wave hits metal all the energy is reflected back. When a wave hits a non-metallic object, some energy reflects back while some continues through. Since the energy returned from non-metallic objects is less than metal, metal targets are more detectable than plastic ones.
- **Target size:** Larger targets simply reflect more energy making them easier to see.
- **Interference from other objects:** There can be many targets embedded in concrete (rebar, wire mesh, radiant heat tubes, conduits, etc.). Seeing deeper targets can be challenging since shallower objects tend to mask deeper ones. This doesn't mean you can't see below the top mat of rebar; it just becomes progressively more difficult reducing your maximum penetration depth.

Reflection Strength

The strength of the reflected GPR wave is a result of the contrast in the dielectric constant (K) between the host material (e.g. concrete) and the target material (e.g. conduit). Dielectric constant is related to the electrical properties of the material.



In the following equation, Reflection Coefficient (R) is calculated based on the differences in dielectric constant between the host (K1) and target (K2) materials. The magnitude of the Reflection Coefficient is always between 0 and 1; the higher number, the easier it is to see the object/interface.

$$R=\frac{\sqrt{K1}-\sqrt{K2}}{\sqrt{K1}+\sqrt{K2}}$$

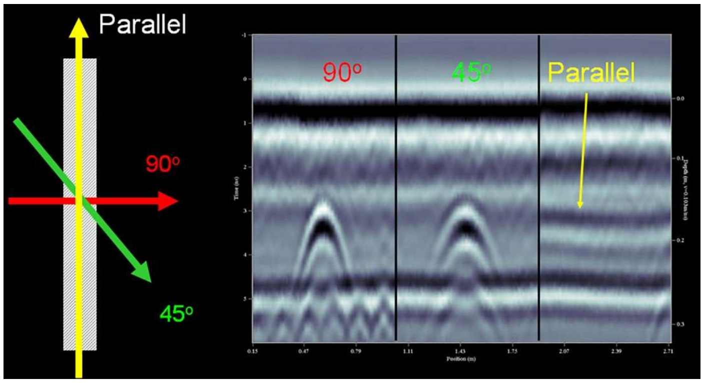
The size of the target you are looking for affects the strength of the returning GPR wave. Larger targets that present a greater cross-section return more GPR wave energy to the receiver.

Resolution

GPR Resolution is often defined incorrectly; it does not refer to the smallest detectable object, but to the ability to resolve (or clearly differentiate) two closely spaced objects.
Resolution can be broken down into detecting objects that are coincident (directly on top of each other) or side-by-side:
Coincident object resolution value depends on the velocity of the GPR wave through the concrete.
Side-by-side object resolution varies with velocity and depth. For example, two objects 10cm deep would need to be about 7cm apart to be clearly resolved.

Depth Determination

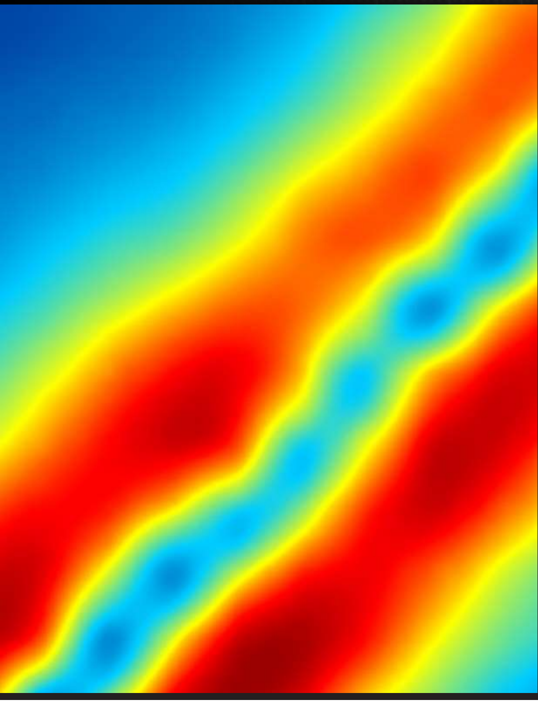
To accurately measure depth, you need the correct concrete type value. Concrete Type (velocity) is the speed at which the wave travels through concrete. This value fluctuates depending on the aggregate type and water content of the concrete. Having an accurate Concrete Type value helps you to accurately determine an object's depth.
MHS calculates concrete type automatically once you have collected data containing hyperbolas.



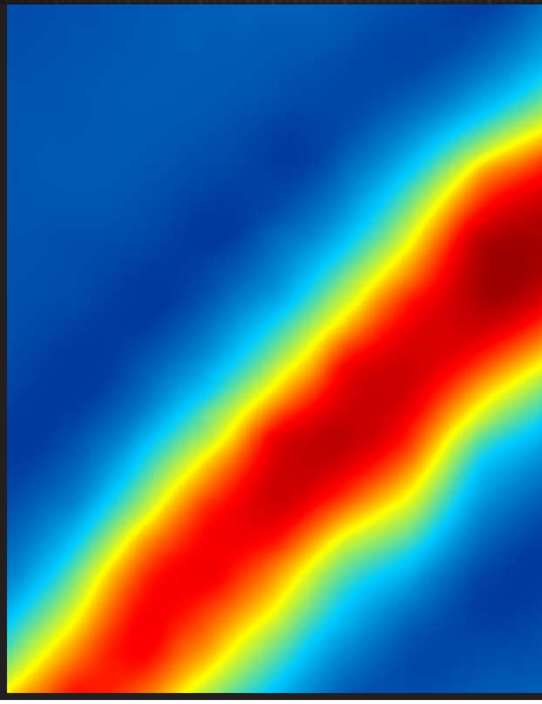
• Cross the target at 90 degrees to generate the "tightest" possible hyperbola.

To create conditions for collecting data with quality hyperbolas, observe the following scanning best practices:

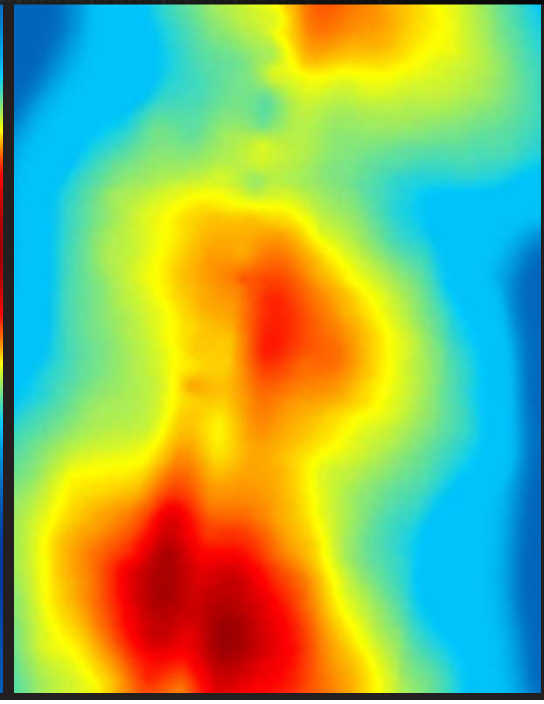
- Cross the target at 90 degrees to generate the "tightest" possible hyperbola. Crossing targets obliquely results in wider hyperbolas and velocities higher than the true velocity.
- Make sure your objects on the screen are not too shallow (less than 1.5 inches). The shape of shallow hyperbolas can be distorted, resulting in incorrect velocity calculations.
- Do not pick up air wave targets. This occurs when the GPR wave detects an overhead pipe or some surface object as the wave travels through the air resulting in a very high velocity. Although seeing airwaves in MHS data doesn't happen often, it is something to be aware of. Normal velocities for concrete shouldbe between 85 and 135.



wires side-by-side in conduit



wires top/bottom in conduit



wires twisted in conduit

Power Cable Detection

The Power Cable Detector (PCD) can help you identify conduits under load, but it is important to understand what you are measuring and how it can be affected. PCD passively measures the magnetic flux (field) generated by current. This field can be influenced by:

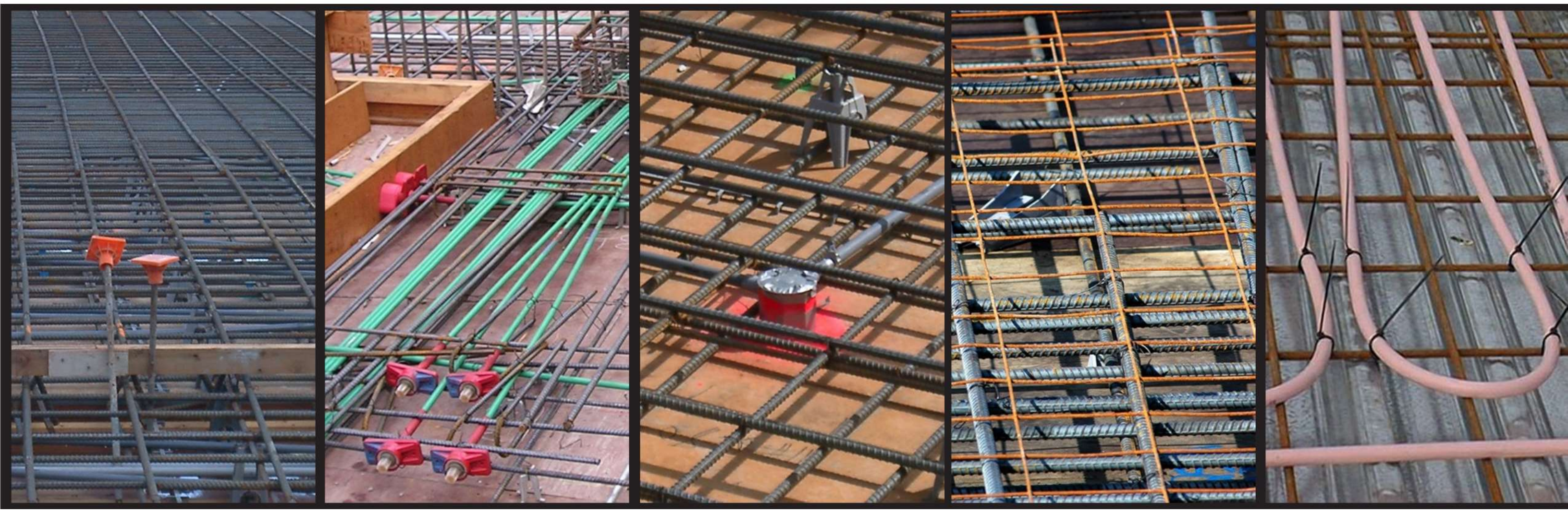
- amount of current in the wire
- depth to the wire
- orientation of the wires (very important)

Power Cable Detection depends on the type of wiring used, how much they are twisted, and wire separation.

This depends on the type of wiring used, how much they are twisted, and wire separation. Depending on the arrangement of the wires, you may see a distinct target or a blurry haze. In the above diagrams, the conduit is the same but the wires are arranged differently in the conduit.

In some cases PCD responses can come from above (transformer boxes, fluorescent lights). Remember, PCD simply supplements GPR data.

Applications for Concrete Scanning



Easy (Routine)

- Locating rebar
- Locating post-tension cables
- Locating metallic and non-metallic conduits
- Locating wire mesh
- Locating radiant heat tubes (easier if they are water filled)
- Locating dowel bar and tie-bars in road/bridge construction
- Detecting a hollow-core slab
- Measuring cover depth above targets
- Measuring asphalt thickness over concrete

Locating rebar, post-tension cables, metallic and non-metallic conduits, wire mesh, radiant heat tubes are routine GPR applications

Medium (Challenging)

GPR can accomplish the following, with some challenges:

- Detecting voids beneath slab-on-grade. Since there is a greater dielectric contrast at the concrete-to-air boundary than there is between the concrete-to-gravel boundary, the areas returning a better reflection compared to the surroundings usually indicate a potential void. Delineating the area extent of a void may be possible; determining the thickness is usually not possible.
- Detecting glass rebar - these returns weak responses:
  - If you are using Line Scan mode, increase the gain.
  - If you collect a Grid Scan where the concrete contains metal rebar in the same grid as glass rebar, the metal rebar will show up, but the glass rebar will not.
- Vertical rebar in columns - when vertical rebar is packed very close together it is hard to resolve one bar from the next.
- Measuring the depth of a concrete slab-on-grade - can be challenging due to the low dielectric contrast for the concrete-gravel interface and the intersecting hyperbola tails from wire mesh. The former results in weak reflections and the latter tends to mask the reflection from the bottom of the concrete interface.

Difficult

The following tasks are very difficult to scan and require a trained eye and sometimes destructive verification:

- Cracks - the best conditions for locating cracks in concrete are when they are in the horizontal plane closer to the surface than the reinforcement. In addition:
    - Cracks are more visible when they are filled with water.
    - Cracks in the vertical plane are difficult to see.
- Corrosion - since corroded rebar reflects less GPR energy than non-corroded rebar, they generate weaker hyperbolas. To improve your chances of detecting corrosion, scan an area large enough to compare hyperbolas and look for anomalies. This may display areas of deteriorated concrete which could be caused by corrosion. Taking a core sample (destructive testing) can help in corrob-orating results.

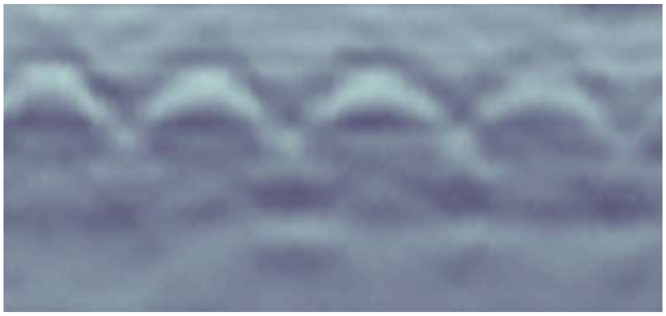
Impossible

- The following tasks cannot be accomplished using GPR:
- Concrete with steel fibres scatters the GPR wave.
- Measuring the diameter of a pipe or rebar: GPR can give an indication of relative size, but not an absolute diameter.

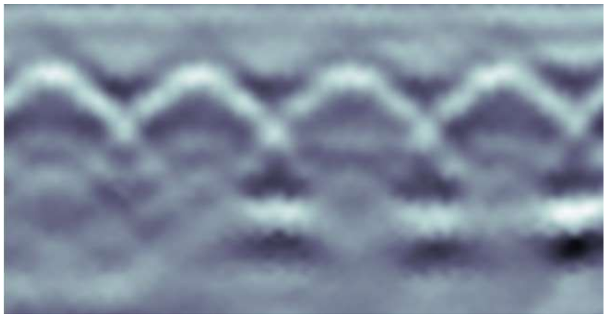
COMPLEX SITUATIONS

New Concrete

When a concrete slab is poured, there is a lot of water that needs to be absorbed during the curing process. Concrete slabs cure at different rates. If you scan a new slab within the first eight weeks after it was poured, your results may not be optimal.



Three day old concrete



Two month old concrete

Metal Corrugated Decking

Slabs that are less than four inches thick with a metal deck underneath may be hard to interpret; thicker slabs are easier to interpret. If there is a conduit in the “trough” of the deck, your best hope for locating it is to use the PCD.

Scanning Roofs

Roofing membrane interfere with wave penetration. To improve your locating chances, remove all roofing material (gravel, tar paper, plywood, Styrofoam).

Terrazzo or Tile

Tile floors themselves are not a problem, but the metal screening underneath the tile acts like a sheet of metal preventing signal penetration.

GPR Best Practices

Grid scans produce better pictures and minimize your risks of incidents.

Knowing GPR principles and theory is only half of a good locator's tool kit. Combining these principles and theories with good GPR scanning techniques in the field completes the package. GPR Best Practices can be broken down into the following categories:

Discussing a Job

When you first talk to a prospective customer about a new job, learn as much as you can about the job and site. This is also a good time to clearly establish customer expectations. Use the following list of possible questions for your customer discussion:

- How old is the concrete? (look out for newly poured slabs)
- What are they looking for? How deep do they think it is?
- How thick is the concrete?
- Is it a suspended slab, slab-on-grade, wall, ceiling, column, or something else?
- Is there anything unusual in the concrete makeup (steel fibers)?
- How large is the scanning area?
- If it's a small area is there adequate room to move the scanner?
- Are there any utilities beneath the concrete? If so, can they be powered so current is flowing through them?
- Will the area be clear of debris and swept?
- Will you (locator) have access to the floor beneath the structure to see how it was constructed?
- Do as-built drawings exist?
- If using MHS with the large monitor, is AC power available at the site?

Arriving at a Job Site

Useful information regarding the structure to be scanned is valuable when reaching conclusions about the targets in the scan area.

- Walk around and below the structure to get an idea of construction practices.
- Is the underside of the slab or wall accessible to scan if required?
- Are there conduits in the slab?
- Are there conduits connected to the underside of the slab?
- Is there a support beam under the slab?
- Is the slab poured on pan deck?
- Are there any electrical panels in the vicinity (could result in false PCD readings)?
- Are there any obvious visual clues about what might be in the slab, such as receptacles or drain covers?

Use MHSDrill Locator to locate a spot on the scan area.

Preliminary Scan

In MHS, enter Line Scan mode and then collect sample data:

- Look for targets
- Can you see bottom of slab?
- Determine direction of rebar
- Does the PCD pick up any power nearby?

Grid Scan

Whenever possible conduct a grid scan; grid scans produce better pictures and minimize your risks of incidents. Conduct a high resolution grid, especially if the grid area is small or if you are expecting weak target responses (i.e. plastic conduit). This will increase your chance of seeing targets running obliquely to the grid pattern.

The following procedure outlines how to run a grid scan:

1. Align the grid properly:
    - Take into account where the core needs to be located, the orientation of the rebar, and any surface obstructions.
    - Align the grid so that you are always running GPR lines into an obstruction rather than starting close to one.

    If you see or suspect there are power conduits in the slab, you may need to increase the size of the (4 ft. x 4 ft. or larger) to see the PCD on your plan maps.
2. After completing grid collection, scroll through the lines on the screen to make sure that the line start position is consistent and doesn’t display large jumps when comparing the lines side by side. If you see a problem line, go back to the grid and recollect it.
3. While scrolling through the lines watch for subtle hyperbolas gradually moving across the images. This indicates a diagonal target to look for during the depth slice analysis.

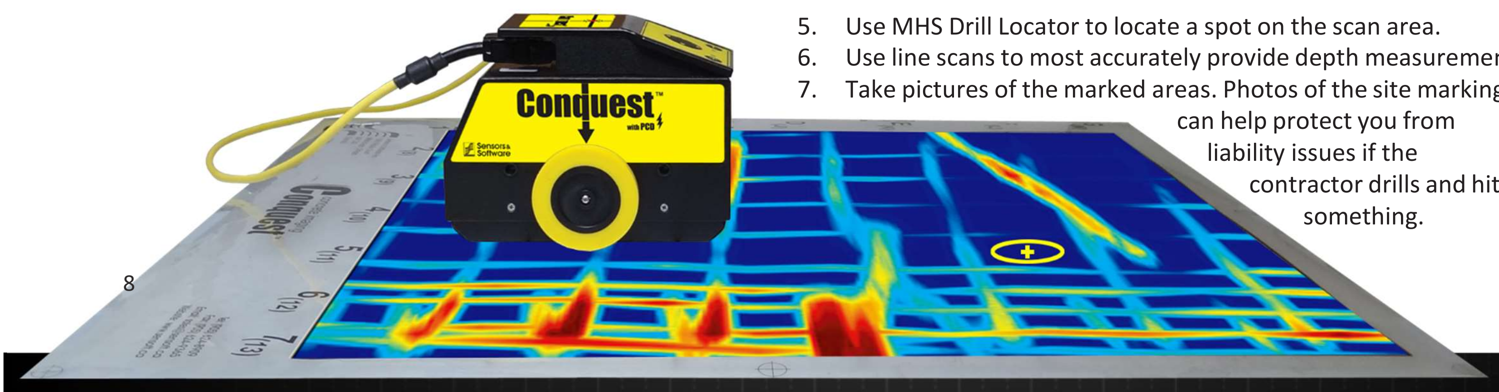
Analysis

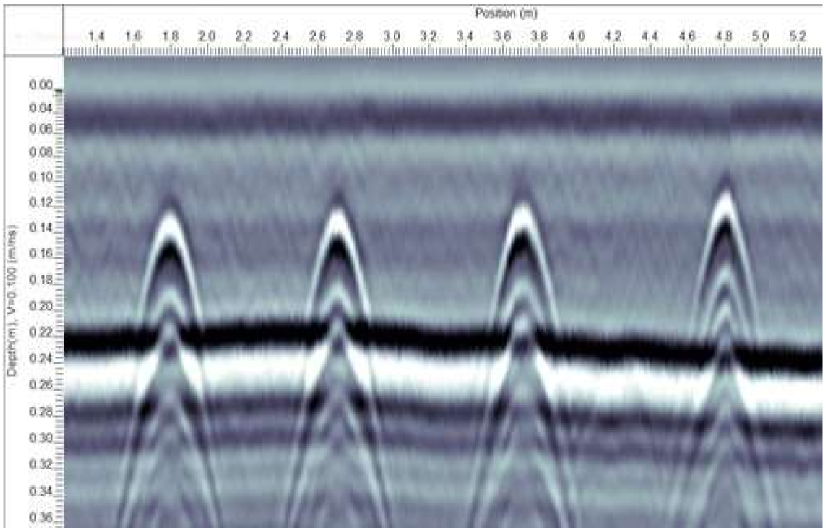
A lot of work has gone into collecting the data, so it is vital that you take the time to properly analyze the data. The following procedure will guide you through the best practices for analyzing data:

1. Review all the depth slices.
2. Cycle through all data lines.

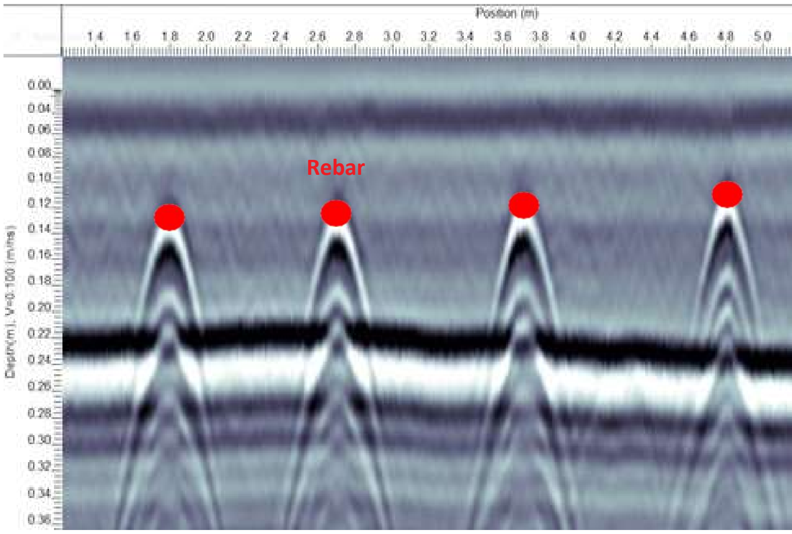
    Make sure all your hyperbolas correspond to targets in your plan map.

    Linear features on a plan-map (especially the shallowest ones) that don’t correspond to a hyperbola in the data lines may be a result of the applied data processing.
3. To differentiate objects, look for telltale signs of objects that deviate from the rebar pattern:
    - Post-tension cables tend to be draped between columns, deeper at the midpoint and shallower near the columns.
    - Conduits may curve and take the most direct path from A to B. Non-metallic conduits also return a lower strength wave than metal objects and rebar.
4. When in doubt mark it out!
    - One way to mark the floor is to pre-punch holes in the vinyl grid at the corners or at several grid line intersections.
    - Make marks on the floor through the holes in the mat.
    - When the grid is lifted off you will be left with a series of reference points on the floor.
    - Do not draw thin lines on the floor to represent objects. Draw them with a certain thickness, as obtained from the screen, usually at least 1.5 inches. You can factor in an error margin of 0.5 inches on either side.
5. Use MHS Drill Locator to locate a spot on the scan area.
6. Use line scans to most accurately provide depth measurements.
7. Take pictures of the marked areas. Photos of the site markings can help protect you from liability issues if the contractor drills and hits something.





GPRSLICE and LineView



Interpretation Module LineView

GPRSLICE and LineView

GPRSLICE’s LineView module allows you to view Line Scan data and individual lines collect- ed as part of a grid. Use LineView to determine object depth and calibrate for velocity. Modifythe Gain setting to create the best looking Line Scan image.

Images can be exported to a picture file, or copied to the clipboard to be inserted into other documents.

Interpretation Module (in LineView)

The Interpretation Module extends the functionality of LineView by allowing you to label GPR features (interpretations) on a Line Scan and export quantitative information (depth, location) to a file.

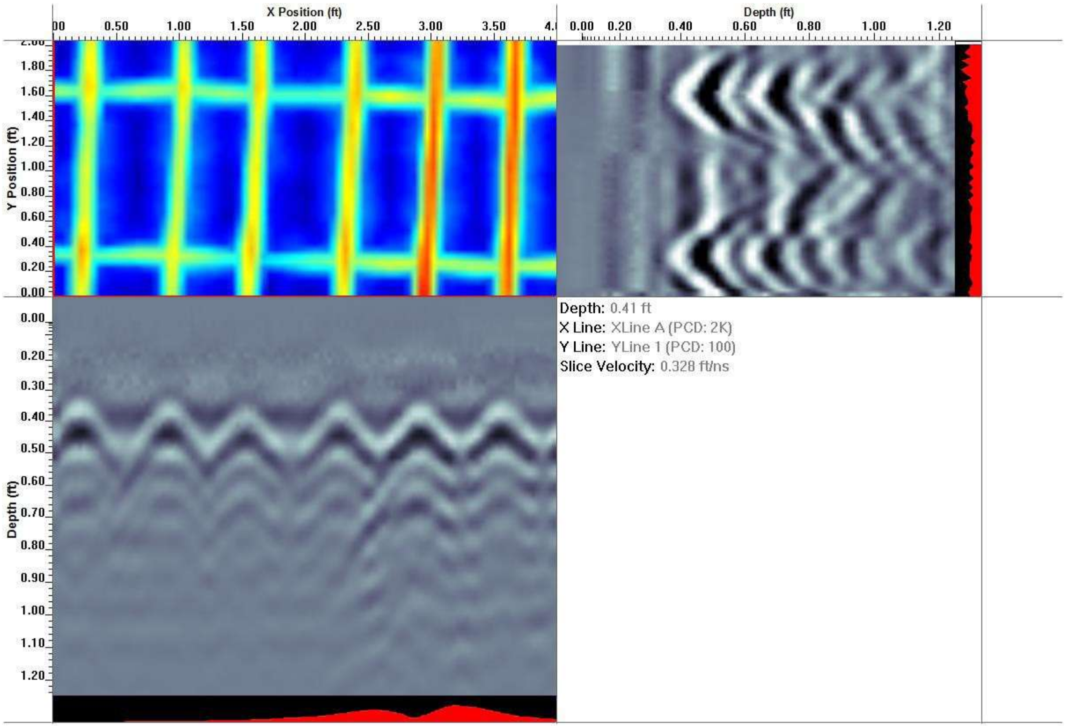
For example, you could pick a series of rebar and export the results to an Excel spreadsheet for analysis.

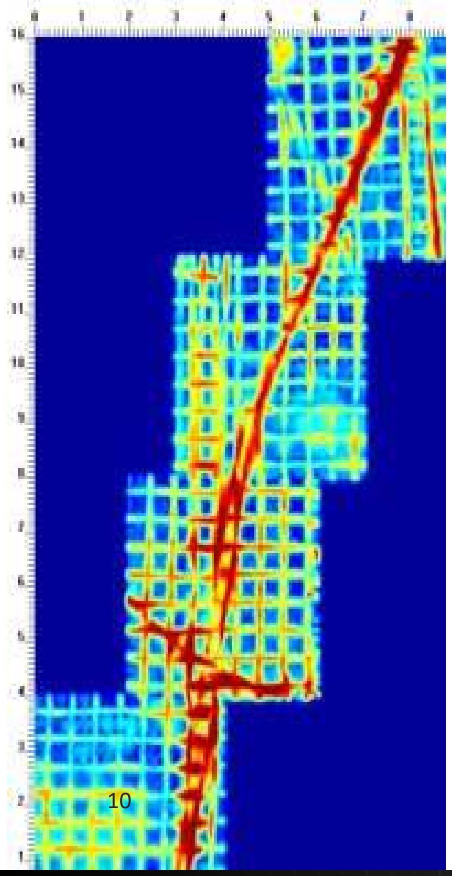
Maximum rebar separation – 1.10 ft
Minimum rebar separation – 0.81 ft
Average rebar separation – 1.00 ft
Maximum rebar depth – 6.3 in
Minimum rebar depth – 3.7 in
Average rebar depth – 5.4 in

Interpretation	Position (ft)	Depth (in)
Rebar	0.753	4.49
Rebar	1.559	4.53
Rebar	2.592	3.70
Rebar	3.695	4.88
Rebar	4.763	5.04
Rebar	5.814	4.96
Rebar	6.672	5.71
Rebar	7.74	5.08
Rebar	8.791	5.20
Rebar	9.684	5.71
Rebar	10.665	5.98
Rebar	11.646	5.91
Rebar	12.749	5.63
Rebar	13.677	5.75
Rebar	14.78	6.06
Rebar	15.761	6.34
Rebar	16.812	6.14

GPRSLICE (3D Preview)

MHS data can be processed in GPRSLICE to create images for your customers or write reports. You can copy Images to the clipboard or export them to a picture file, export data to a 3D (.hdf) file to import into Screening eagle) or a (.csv) file for importing into Excel, AutoCAD, and GISsoftware. 3D Preview allows you to easily view the depth slices and cross-sections at the sametime.





GPRSLICE and SliceView

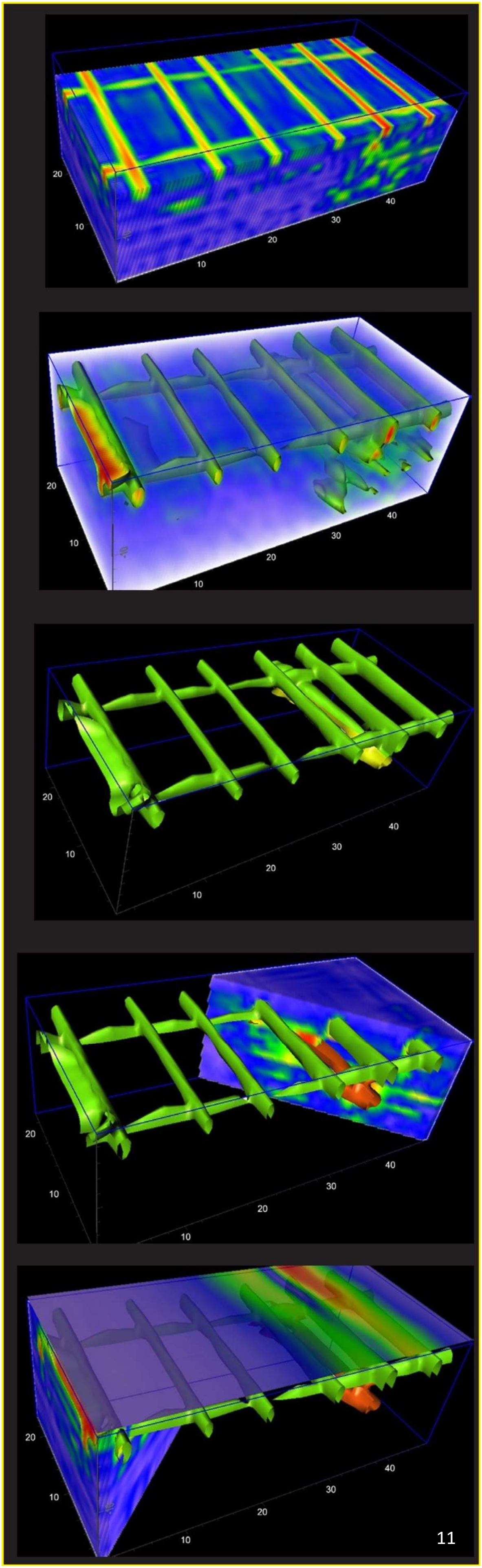
While MHS grids are restricted to certain sizes, SliceView can create plan maps from anysize grid data and piece together grids, provided you know the relative offsets.

In the following example, four MHS grids were collected each measuring 4ft. x 4ft. Thegrids were combined using SliceView.

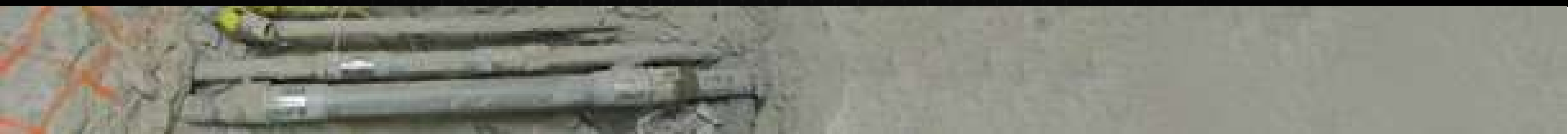
You can copy Images to the clipboard or export them to a picture file, export data to a 3D (.hdf) file to import into Voxler, a (.csv) file to import into Excel, and a (.grd) file for Surfer.

Screening eagle

MHS software enables you to see data in a 3D cube using Screening eagle software. Screening eagle is primarily a presentation and visualization tool,and while it is powerful software, itcan also take some time and manipulation to create the ideal image. The mages on the right sideare displayed via Screening eagle.



Tips and Tricks



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Power Cable Detector

The Power Cable Detector detects objects that carry 50 or 60 Hz current by measuring the magnetic field created from the AC current; the line must under load at that time. It will not detect DC current, telephone wire, fire alarm, or fibre-optic cables.

1. In Line Scan, conduct a scan to assess the area.
2. Refer to the PCD indicator which displays a graph of magnetic fields under the Line Scan GPR image along with a number indicating the maximum scale on the graph.
3. If the graph shows a spike, or if the maximum number rises to greater than 400, there may be power in the area. If so, collect a 4ft x 4ft (1200mm x 1200mm) grid (or at the very least, a 2ft x 4ft (600mm x 600mm) grid).

Since a magnetic field is not an exact measurement, be aware that an embedded object generating a PCD response may be displayed as a haze instead of a well-defined feature on the PCD image.

Measuring Diameter

GPR cannot measure the diameter of objects. However, if you encounter rebar running in both directions and one is obviously over top of the other you may be able to estimate bar diameter:

1. In Line Scan, measure the depth of the North-South rebar.
2. Measure the the East-West rebar.
3. Calculate the difference between the two measurements.

The result is a very good estimate of the bar diameter (assuming the rebar are contacting one another).

Depth Measurement Accuracy

The accuracy of depth measurements depends on having the correct concrete type (velocity) as well as consistently picking the top of the hyperbola. Absolute accuracy will be +/- 5% to 10% of measured value. Relative measurements between objects should be +/- 1% (since variables are fixed).

Scanning Large Areas

With a little extra work, you can use MHS to scan areas of any dimension.

1. Collect individual lines in Line Scan.
2. The longest line that can be collected and saved in Line Scan mode is 150 feet or 50 m. (on the older MHS Enhanced models, the longest line that can be saved in Line Scan mode is 21 feet or 6.4m).
3. Keep accurate notes about the direction and orientation of every line so you can collect different size grids with different line spaces.
4. To display an image, download the data to your computer and run it through SliceView.

Piecing Grids Together

Regular MHS grids collected individually can be joined in SliceView (using the GFP_Edit utility) provided you know the relative offsets of all the grids.

Filtering

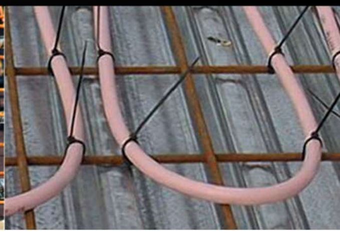
Some scan areas have very shallow targets. In these situations, seeing the top of the hyperbola can be difficult because the direct wave band appears at the top of the raw scan. To remove any flat band/horizon, adjust the Filter to make the tops of hyperbolas easier to see.

Note: Adjusting the Filter also removes the bottom of concrete, so use it wisely and appropriately.

FAQ







Q: How fast can I survey?

A: MHS's patented DynaQ feature collects the best quality data for a given speed. The following chart explains what the colors mean:

- Dark blue: collecting best quality data
- Light blue: lower quality data, but acceptable
- Yellow: lowest quality data - may be pixelated in places. You may need to recollect this line in grid mode.
- White: too fast, skipping data! You will have to recollect this line in grid mode.

Q: Can I collect a grid in only one direction?

A: Technically yes, but it is not recommended. Remember, you will only pick up objects running perpendicular to your scan direction so it is easy to miss objects running parallel to the scan direction.

Q: Is MHS harmful to any people or equipment?

A: All MHS software equipment meets government emission levels; to learn more, refer tothe manual for exposure limits. While we can't guarantee all possible scenarios, MHS has not been known to interfere with any equipment.

Q: My driller hit an object that wasn't marked out. What happened?

A: When investigating an accident, consider the following factors:

- External: factors beyond the control of the person scanning. For example, was the hole drilled in an area that was scanned?
- Situational: conditions present in the concrete which make GPR scanning difficult or not feasible. For example, new concrete or steel fibers
- Procedural: were proper procedures followed for setting up a survey grid and acquiring data?
- Technical: there may be technical reasons (physics of radar) why the object was not seen. For example, the object is too small or buried too deep

Q: Can I skip lines in my grid?

A: In general, it is not recommended, but in some situations (confined spaces or obstructions in the grid) you can skip lines, but the resulting plan map will be missing data from that area.




Case Studies

Each scan is unique. Attempting to cover all the situations you will encounter while scanning are too many to accurately record. The following case studies have been included to outline the principles described in this document (Theory, Application Difficulty, Best Practices, and Software) and describe how to use the appropriate software for analysis and output.

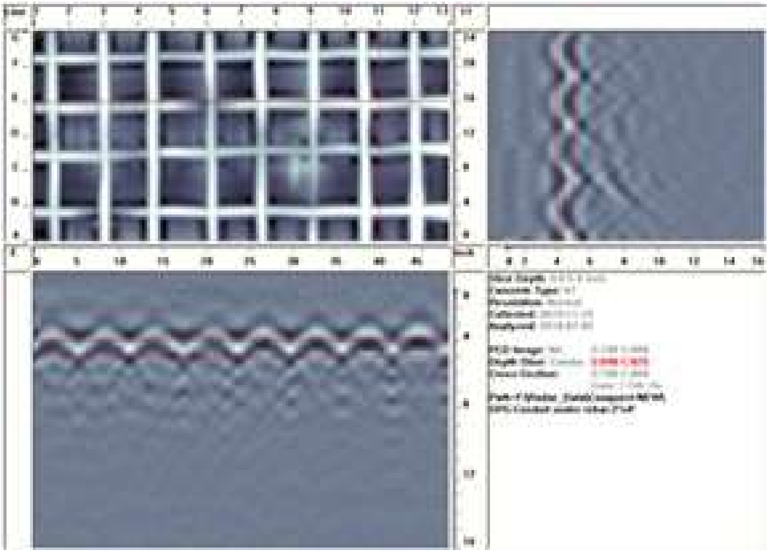
Conduits under Rebar

Theory: Penetration (interference)
Application Difficulty: Easy
Best Practices: Grid Scan
Software: MHS View

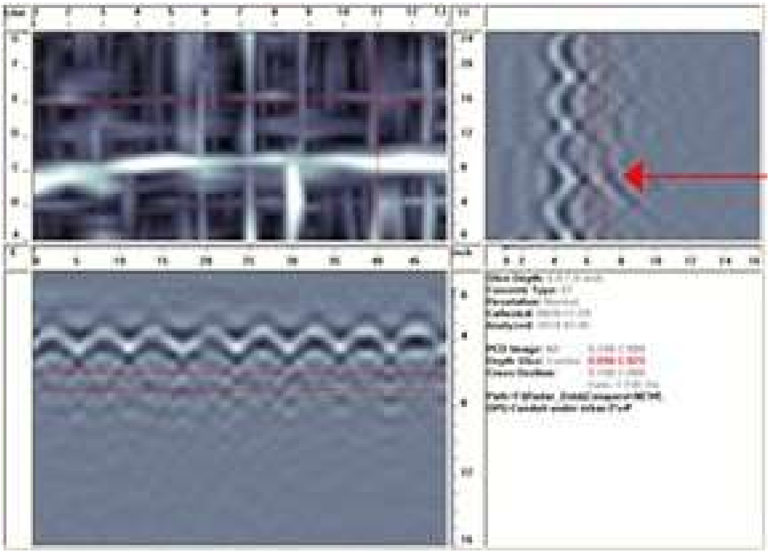
Conduits beneath rebar can be difficult to detect.

1. After collecting a grid over an area, carefully review the plan map images and raw data lines.
2. In MHS View, scroll through the data lines to search for subtle changes.
   If the conduit has current flowing through it, then using the PCD response may help (see the Power Cable Detector case study).

In the following example, the conduit is fairly easy to see in the depth slices. You can confirm this by looking at the hyperbola in the raw data.

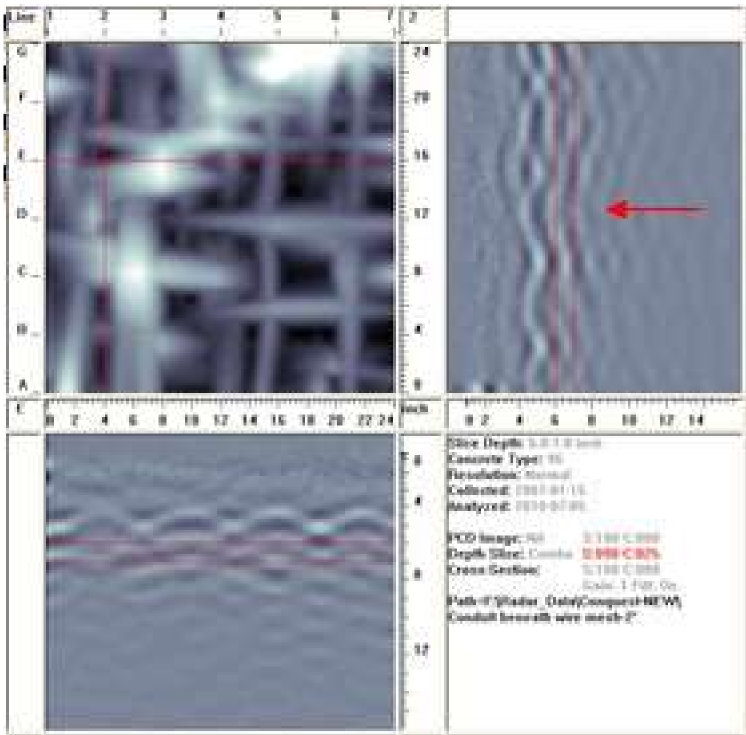


4-to-5-inch rebar

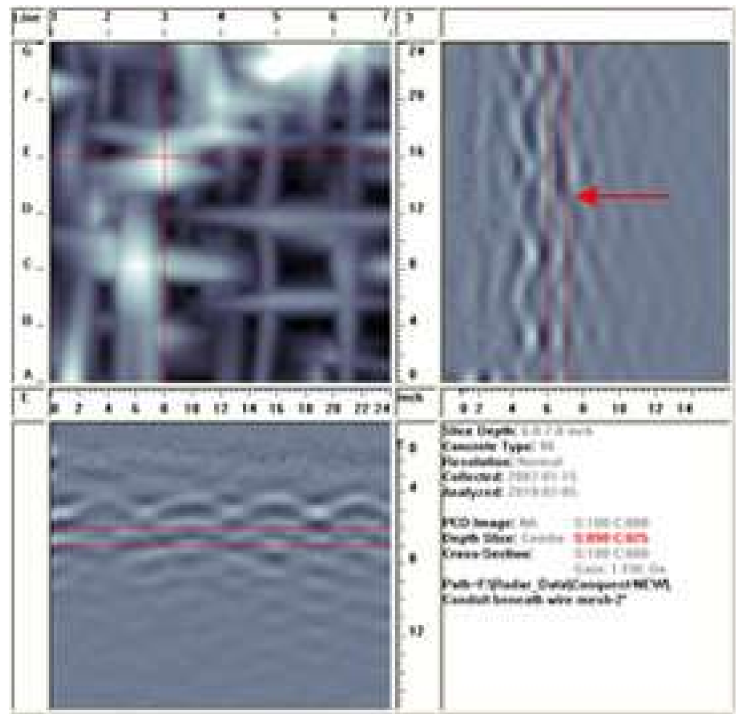


6 to 7 inch conduit

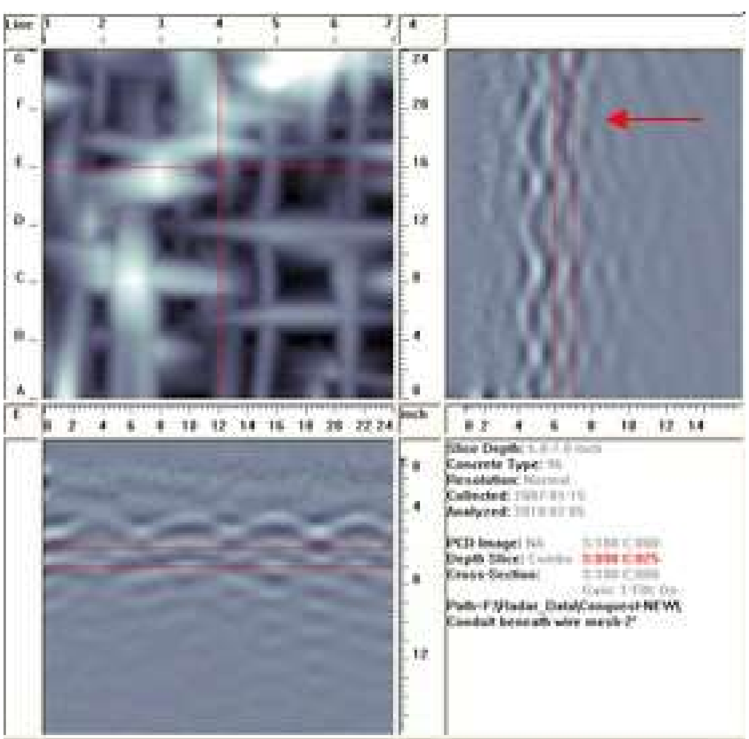
The next example displays how the hyperbola moves in the line scan data for a conduit running at an angle. The following images track the subtle hyperbola changes in the line scan data as the line number changes:



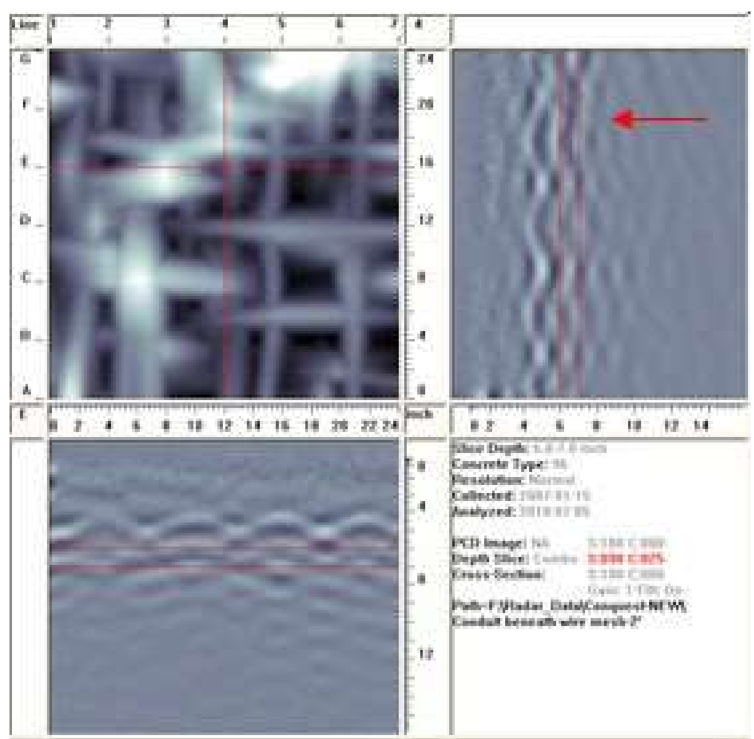
Line # 2



Line # 3



Line # 4



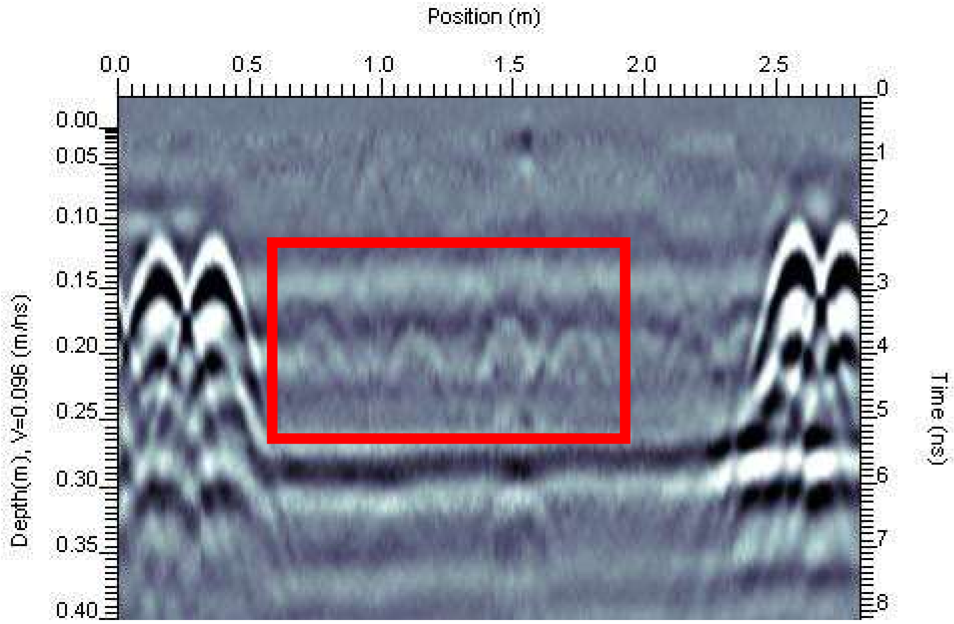
Line # 5

Glass Rebar

Theory: Reflection Strength
Application Difficulty: Medium
Best Practices: Discuss with customer, line scan
Software: MHSView, LineView

Glass rebar is detectable, but returns weaker hyperbolas in comparison to metallic objects. It is best to try to detect glass in line scan mode and adjust the gain to make them more visible.
If you collect a grid, be aware that high amplitude steel rebar may dominate and hide the lower amplitude returns from the glass rebar.

In this example steel rebar is returned as strong hyperbolas, but the more faint hyperbolas in the indicated area are generated by the glass rebar.



MHS detects glassrebar

In MHS, you would need to set gain to 4 to see this response. Having prior knowledge thatthe slab may contain glass rebar would alert you to setting your gain higher during preliminary scans.

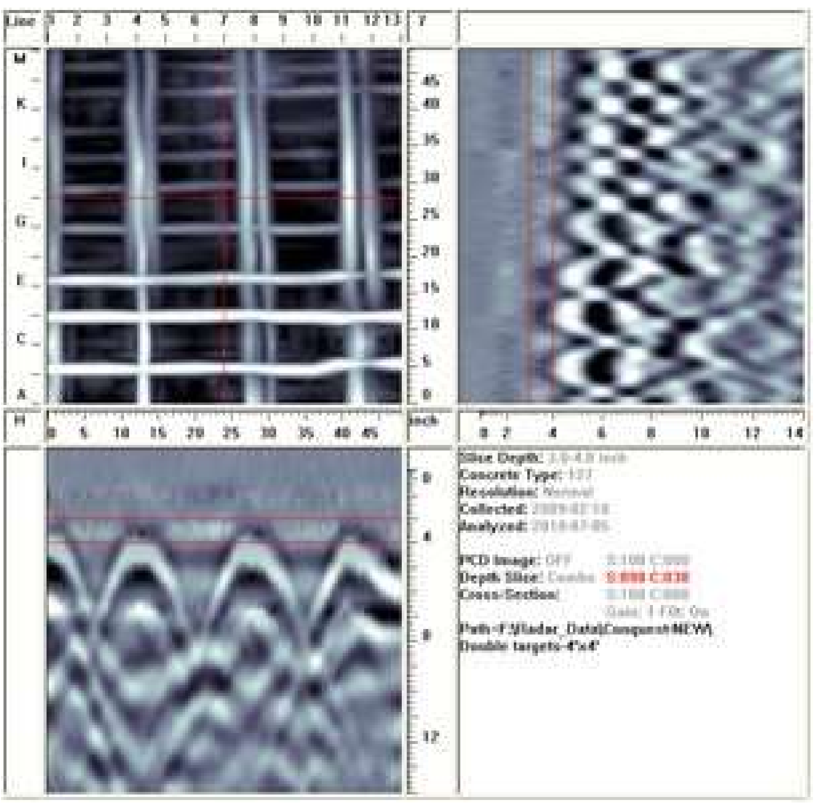
Double Targets

Theory: Resolution
Application Difficulty: Easy
Best Practices: Grid scan
Software: MHSView

In certain engineering applications, you may need to determine the layout and amount of reinforcement within a structure.

Sometimes reinforcement is laid side-by-side which results in double targets appearing on the depth slices. In other situations, they may appear as a single target, but you will need to look at the raw data hyperbolas.

In this example, the deformed (or non-symmetric) hyperbolas provide clues that the North-South rebar are actually in pairs, side-by-side.



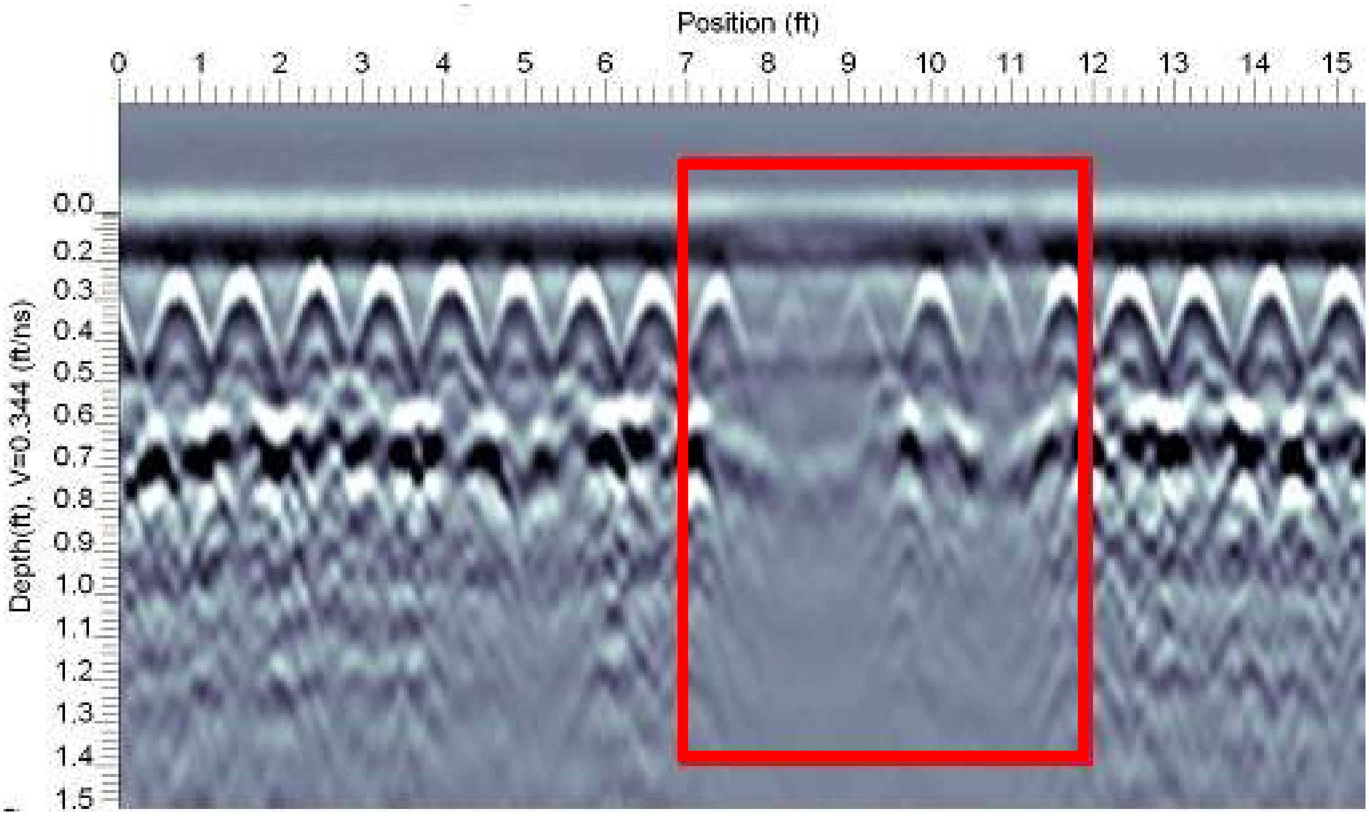
The deformed (or non-symmetric) hyperbolas provide clues that the North-South rebar are actually in pairs, side-by-side.

Corrosion

Theory: Reflectivity
Application Difficulty: Difficult
Best Practices: Preliminary scan
Software: LineView, Interpretation Module

Corroded rebar scatters the GPR waves and returns less energy than intact steel rebar. This response is related to higher GPR wave losses in the deteriorated concrete near the corroded rebar.

In the following example, lower amplitude responses from the reinforcement suggest there is an anomaly between 7 and 12 ft.; the weak response from the bottom of the slab confirms this. Destructive testing tells us that this response is caused by corrosion; you could not reach that conclusion by only looking at the GPR data. This anomaly could also be caused by a change in the concrete properties above the rebar in the area of interest, such as a repaired section of concrete.

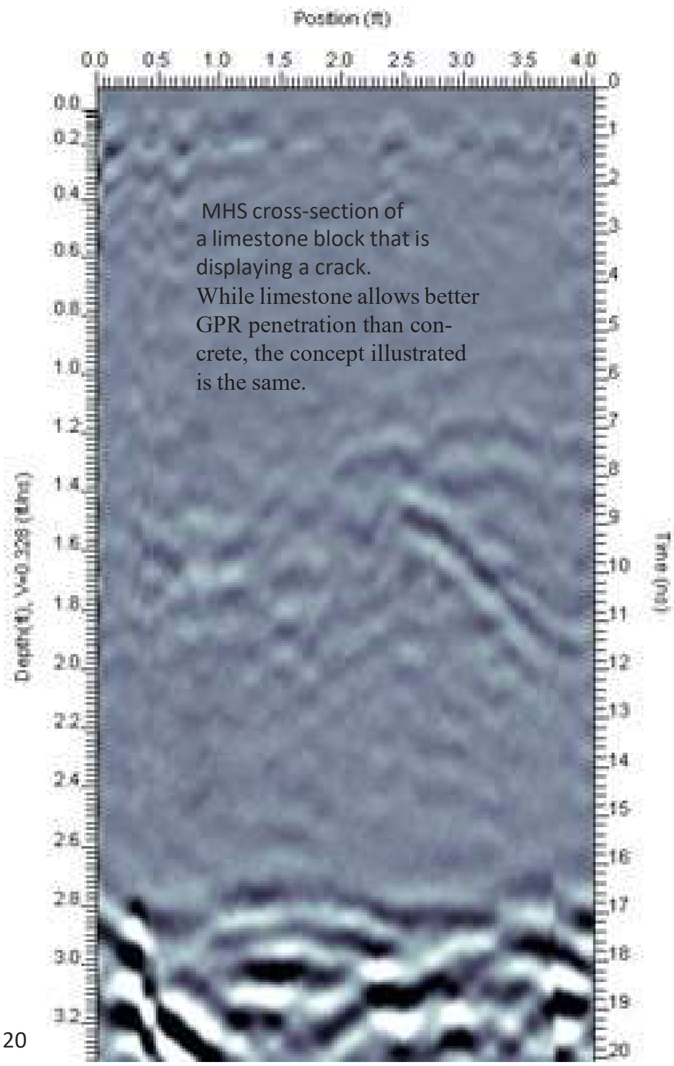


Cracks

Theory: Penetration (diameter and interference)
Application Difficulty: Difficult
Best Practices: Discuss with customer, line scan
Software: LineView, Interpretation Module

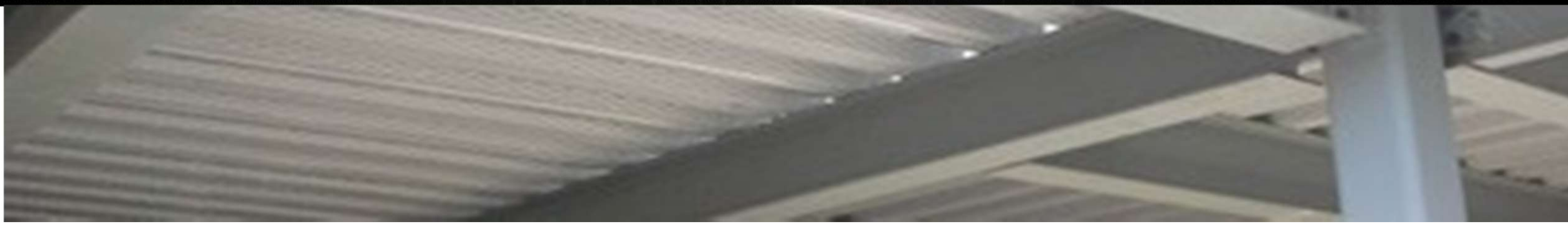
Cracks in concrete are very hard to find. Success depends on the orientation of the crack (horizontal or vertical), its location in the slab (above or below rebar), its size, and whether it is filled with water.

In this example, we scanned a limestone block that is displaying a crack, spreading at an angle. Since the crack is in the horizontal plane, it is detectable.



MHS cross-section of a limestone block that is displaying a crack. While limestone allows better GPR penetration than concrete, the concept illustrated is the same.

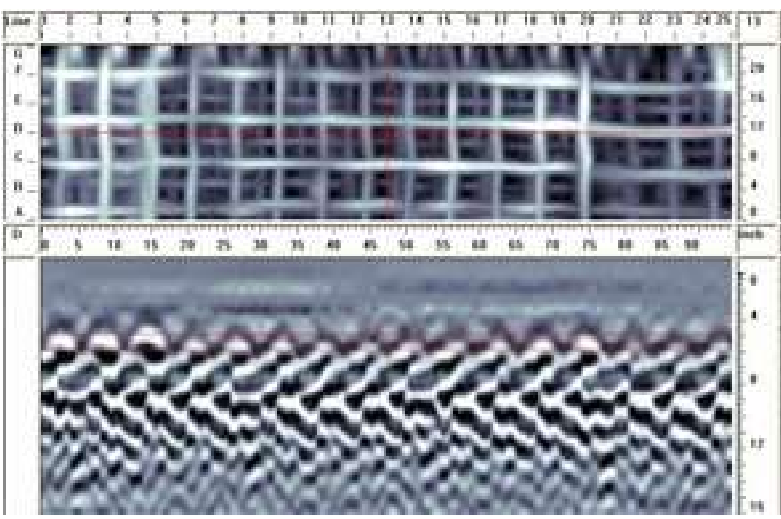
Corrugated Metal Decking



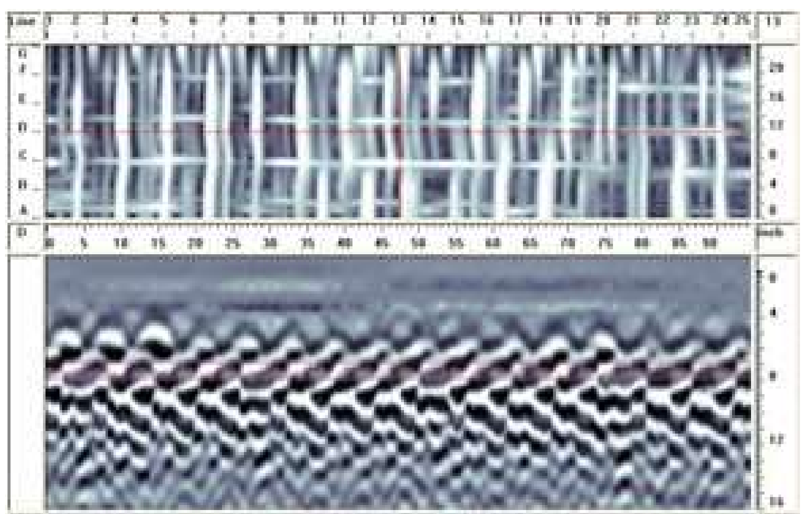
Theory: Penetration (interference)
Application Difficulty: Medium
Best Practices: Arrival at job site, line scan
Software: LineView, MHSView

Corrugated metal decking (Q-Decking) is a metal structure with peaks and troughs. The concrete slab poured above it is usually four to six inches thick. The bottom of the deck provides a solid GPR reflection because it is metal which also creates an interference pattern because of the peaks and troughs. The resulting images may be difficult to interpret. In general, the thicker the concrete, the easier it is to interpret what is between the surface and the metal.

In the following scenario, there is rebar or wire mesh in the concrete above the decking making the scan results hard to interpret. The strong, slightly angled reflection from the deck is a common Q-Decking response.



Depth is 5 to 6 inches



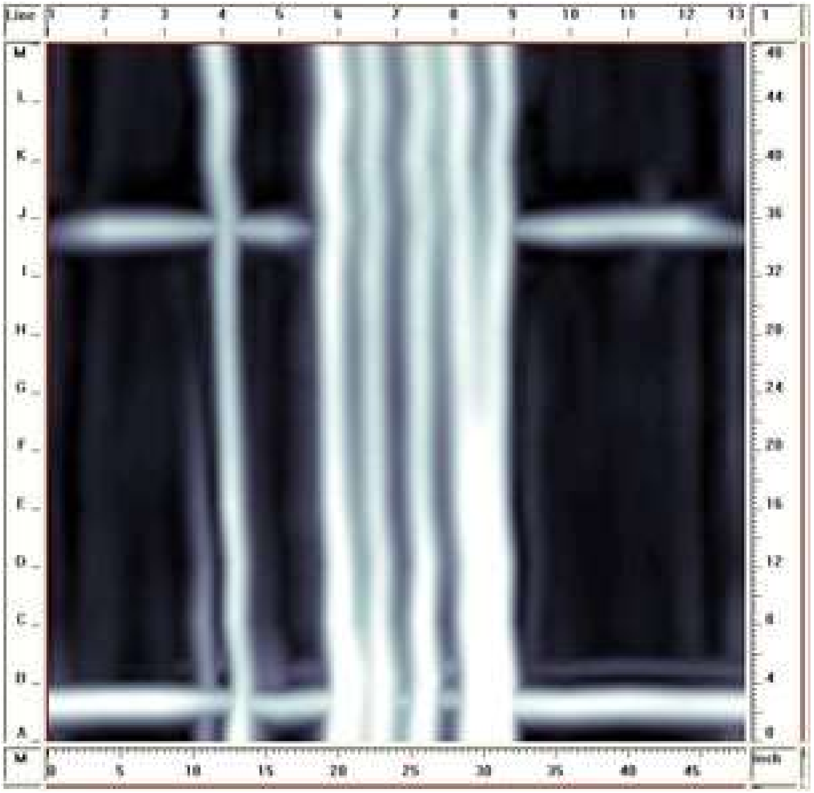
Depth is 7 to 8 inches

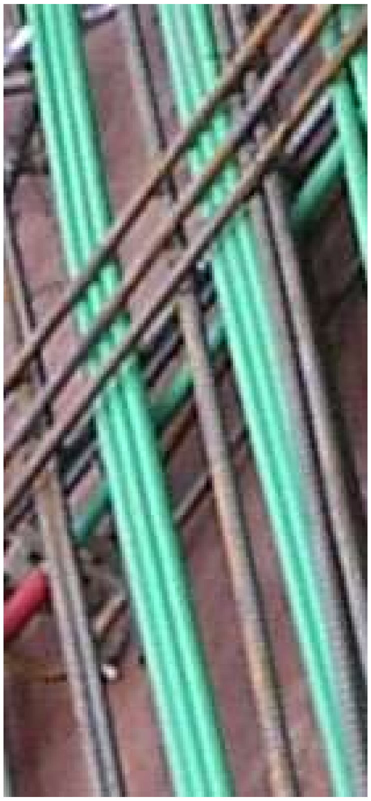
Post-Tension Cables

Theory: Resolution
Application Difficulty: Easy
Best Practices: Grid scan, large area mapping
Software: LineView, MHSView, SliceView, Screening eagle

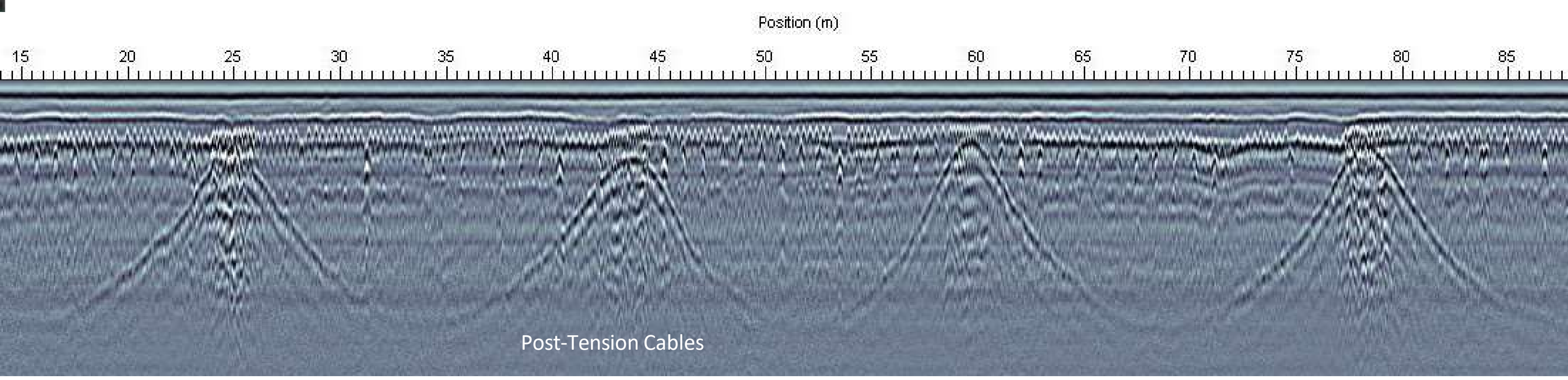
Though locating post-tension cables is easy, distinguishing between post-tension cables and rebar is more challenging. To do this, you need to understand the following characteristics of post-tension cables and look for the tell-tale response:

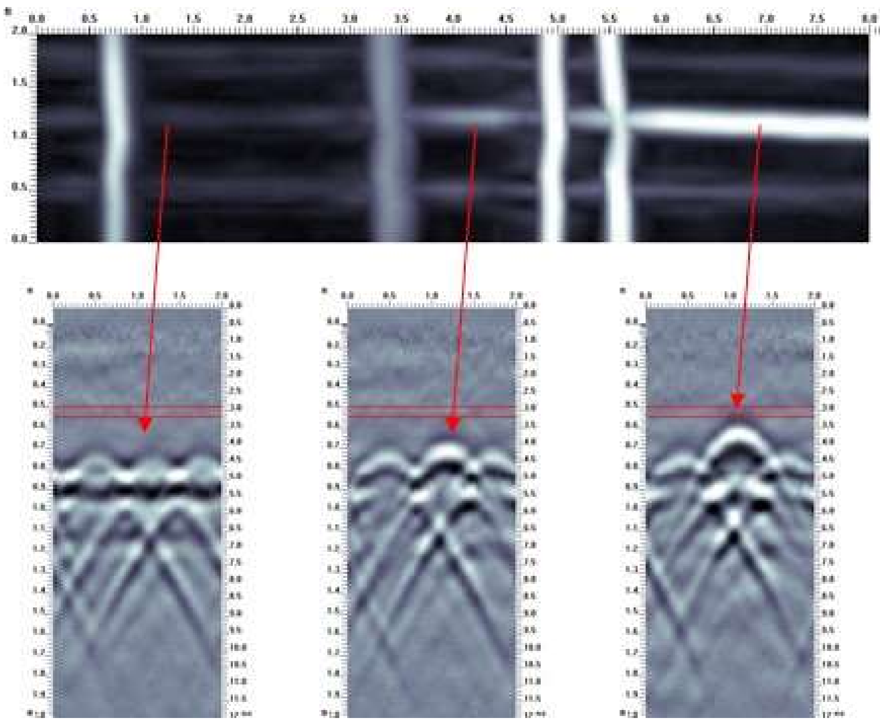
- Post-tension cables are often bundled together
- Post-tension cables change depth in a slab





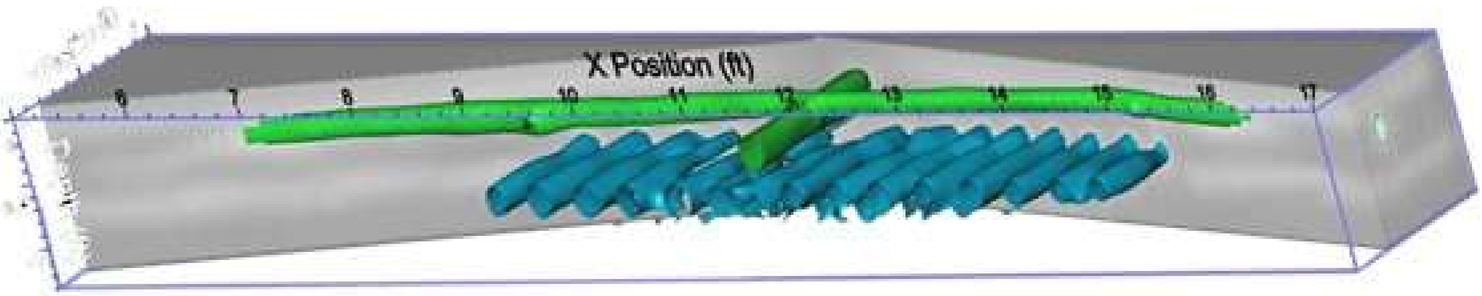
In the line scan image below, MHS was run parallel to a post-tension cable (the hyperbolas are from rebar crossed perpendicularly). The vertical dimension is highly exaggerated (approximately 1m depth window and 50m profile length) to show that PT cable varies in depth between 20cm and 80cm. This is an extreme case of a large depth change; post-tension cables usually exhibit a smaller depth variation.





The next set of images is a good example of correlating the depth slice image with line scan data to see the vertical change of the post-tension cable.

Creating a 3D image in Screening eagle helps to visualizethe structure of a post-tension cable.

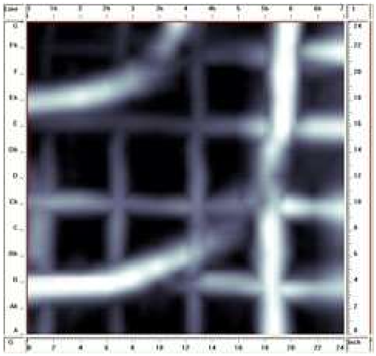


Radiant Heat Tubes

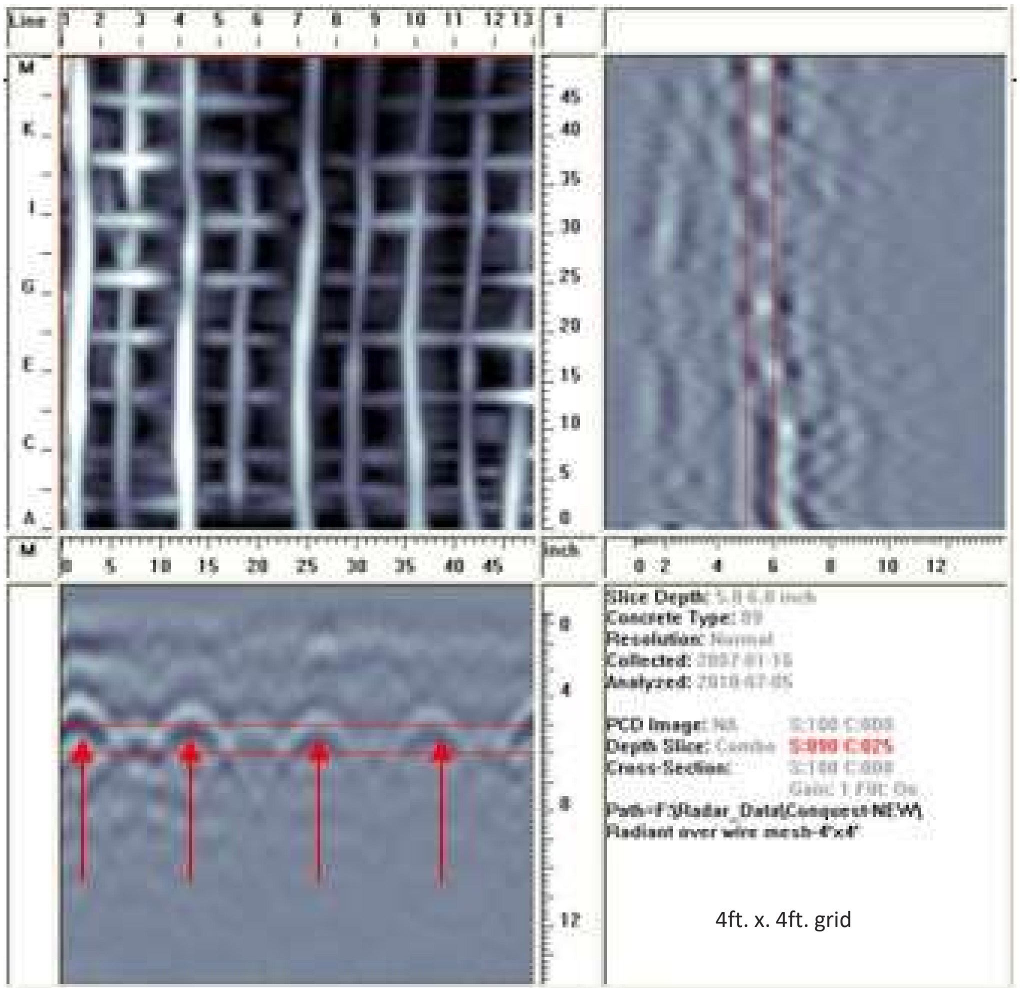
Theory: Reflection
Application Difficulty: Easy to Difficult
Best Practices: Grid scan, large area mapping
Software: MHSView, SliceView

Radiant heat tubes are laid on top of rebar or wire mesh in concrete. Detecting them is fairly easy when they are filled with water; otherwise it is difficult to locate small, empty, non-metallic conduits. The best way to differentiate radiant heat tubes from rebar is to scan near the edges of the room where the heating tubes normally curve.

The following images are display grid scans of 2ft. x 2ft. and 4ft. x 4ft. In the larger scan (right) the line scan data shows that the shallower hyperbolas are the radiant heat tubes, while the deeper ones are rebar.



2ft. x. 2ft. grid



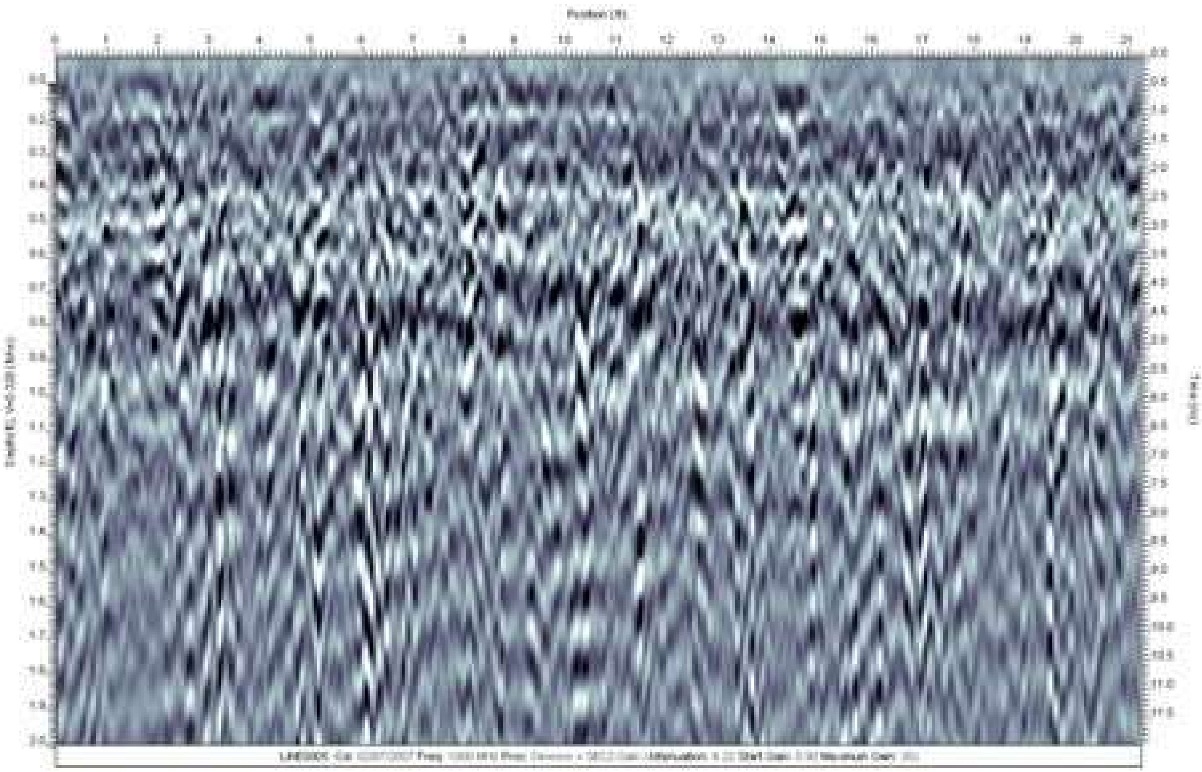
4ft. x. 4ft. grid

Steel Fibres

Theory: Penetration
Application Difficulty: Impossible
Best Practices: Discuss with customer
Software: LineView

Concrete containing steel fibers cannot be scanned by GPR. Steel fibers add to the overall concrete conductivity and completely scatter the GPR signal.

If your scan returns data similar to the following cross section image, you can conclude that the concrete contains steel fibers.

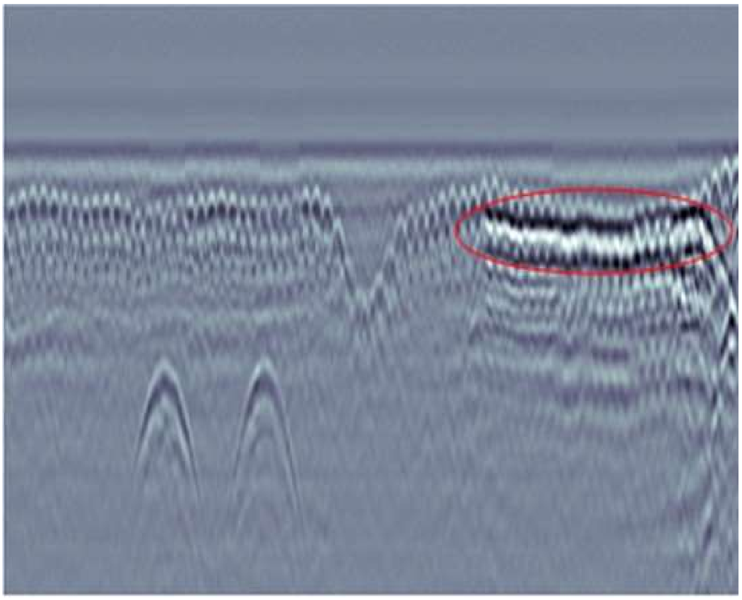


Voids

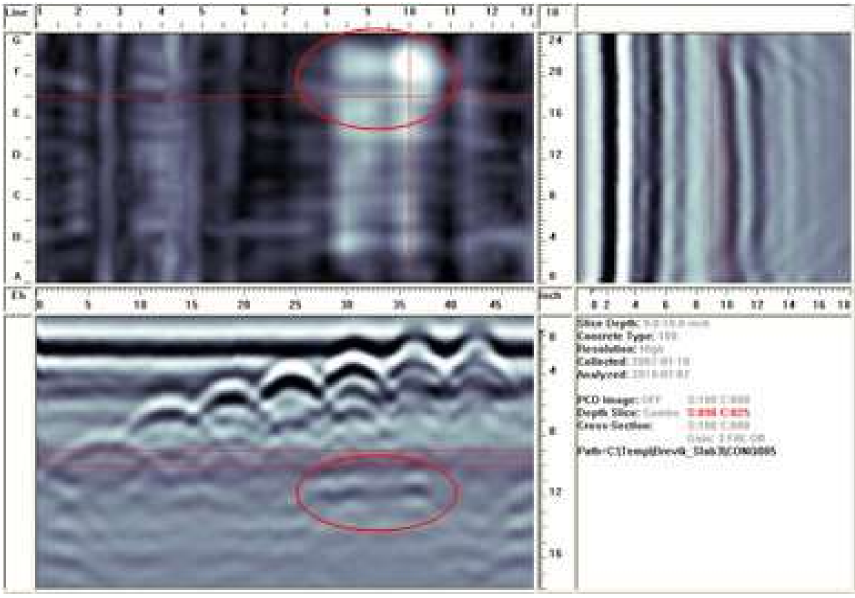
Theory: Reflection Strength
Application Difficulty: Medium
Best Practices: Scan large area, analysis
Software: LineView, SliceView, Interpretation module

The size of a void and its proximity to rebar are the main factors for determining whether you can detect voids. Most commonly, people want to locate voids beneath a slab-on-grade to prevent a possible slab collapse if it is heavily loaded. MHS cannot measure “honeycombing”voids in concrete.

GPR can detect voids beneath a slab-on-grade because there is a change in reflectivity compared to the normal gravel base. An empty void reflects better than the concrete-gravel interface, and a water-filled void reflects even better.
It is unlikely you will be able to measure the thickness of a void, just the extent of its area.

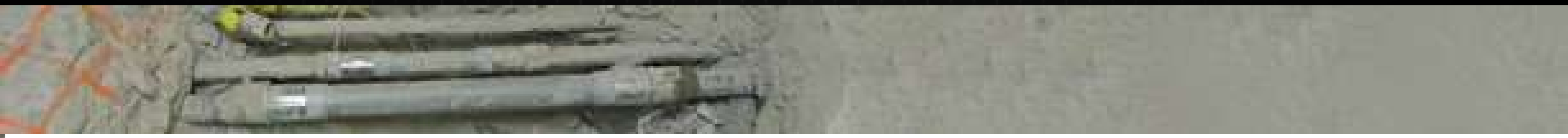


Line scan view displaying a void just under the concrete slab.



This 2ft x 4ft grid displays a Styrofoam block in concrete. The raw data on the bottom displays a flat reflection where the wave hits the top of the Styrofoam block.

Power Cable Detector



Always use line scan mode first to see if there is a reading on the PCD scale.

Look for value that exceeds 400, or spikes in the graph.

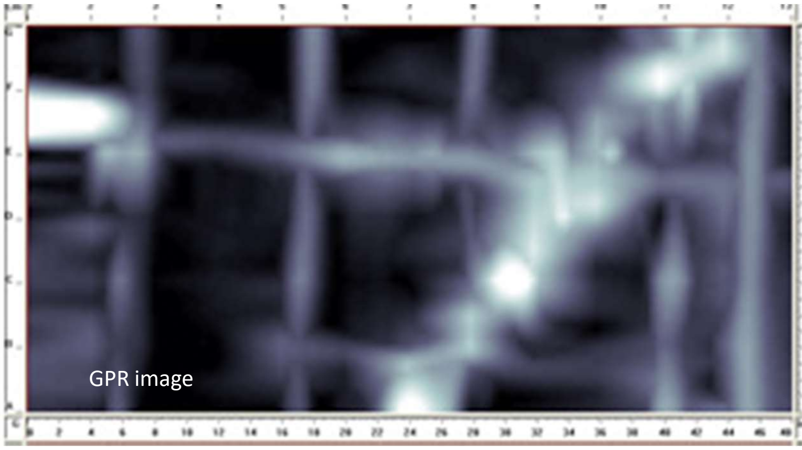
Theory: Power Cable Detector (PCD)
Application Difficulty: Easy
Best Practices: Scan large area
Software: MHSView

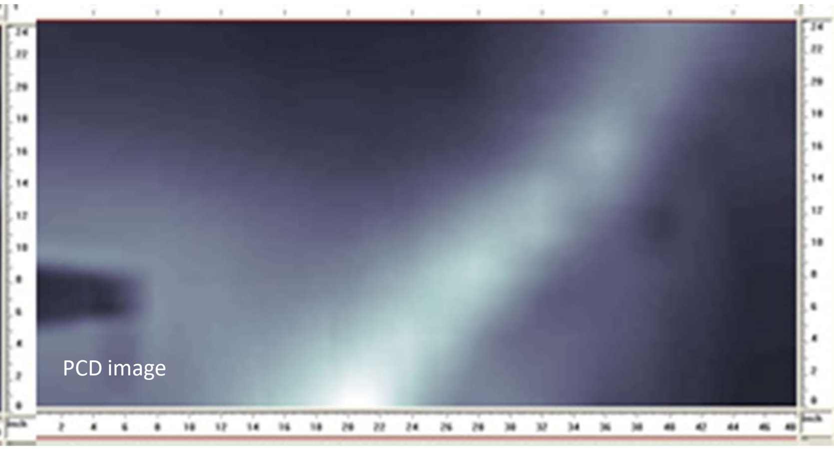
PCD only detects cables that have AC current flowing through them. PCD will not detect phone lines, fire alarm wire, or fiber-optics.

Always use line scan mode first to see if there is a reading on the PCD scale. If you receive a response, it indicates the presence of power in the vicinity.

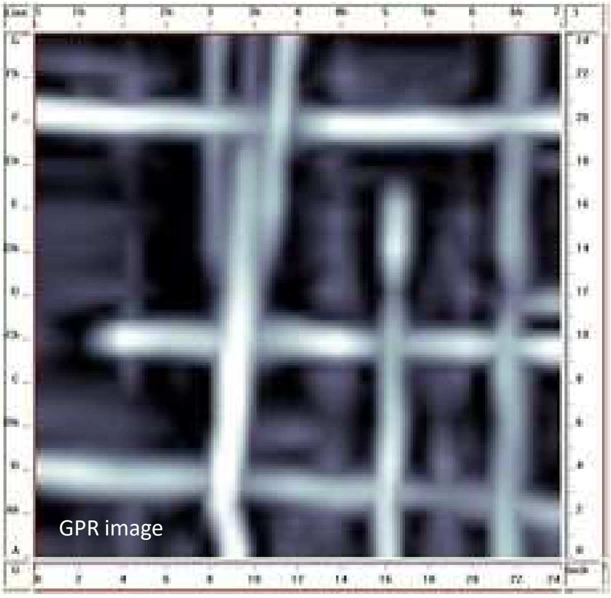
Pay close attention to the values displayed on the left side of line scan as it indicates the range for the graph. The scale “normalizes” or adjusts itself once you terminate a line. For example, if you collected data and the PCD shows all red from top to bottom, stop the line and allow the scale to adjust itself. Collect data again to get an accurate value. Conversely, if the scale is set to a high value, scan some data, let the scale adjust itself, and then rescan the same area.

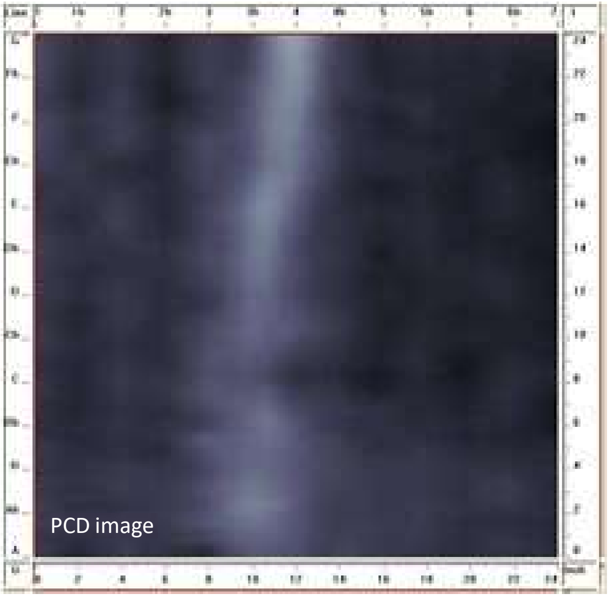
When the value exceeds 400, or there is a spike in the graph, it may indicate that there is something in the scan area. If you have two targets, one under heavy load and a lighter one, the stronger response (heavy load) might dominate and make it hard to see the weaker target. Once you know something may be present, collect a grid scan. Always scan a large enough area, usually at least 4ft x 4ft (1200mm x 1200mm). PCD targets can appear as very broad responses which may not be distinct in 2ft x 2ft (600mm x 600mm)grids.



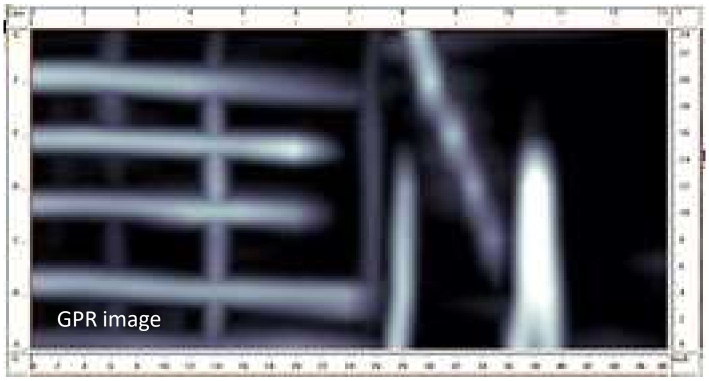


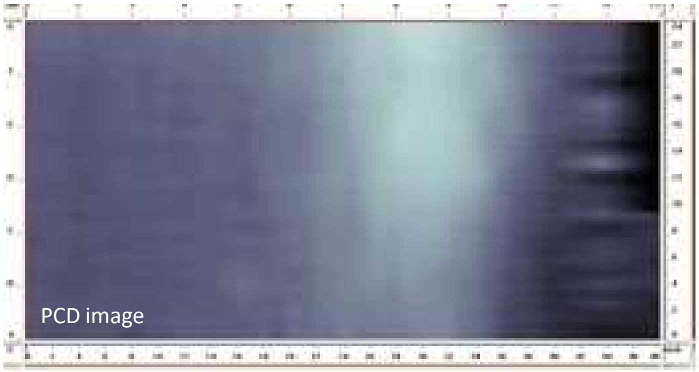
Since the GPR and PCD responses line up, it’s obvious that the diagonal object is a current carrying conductor.





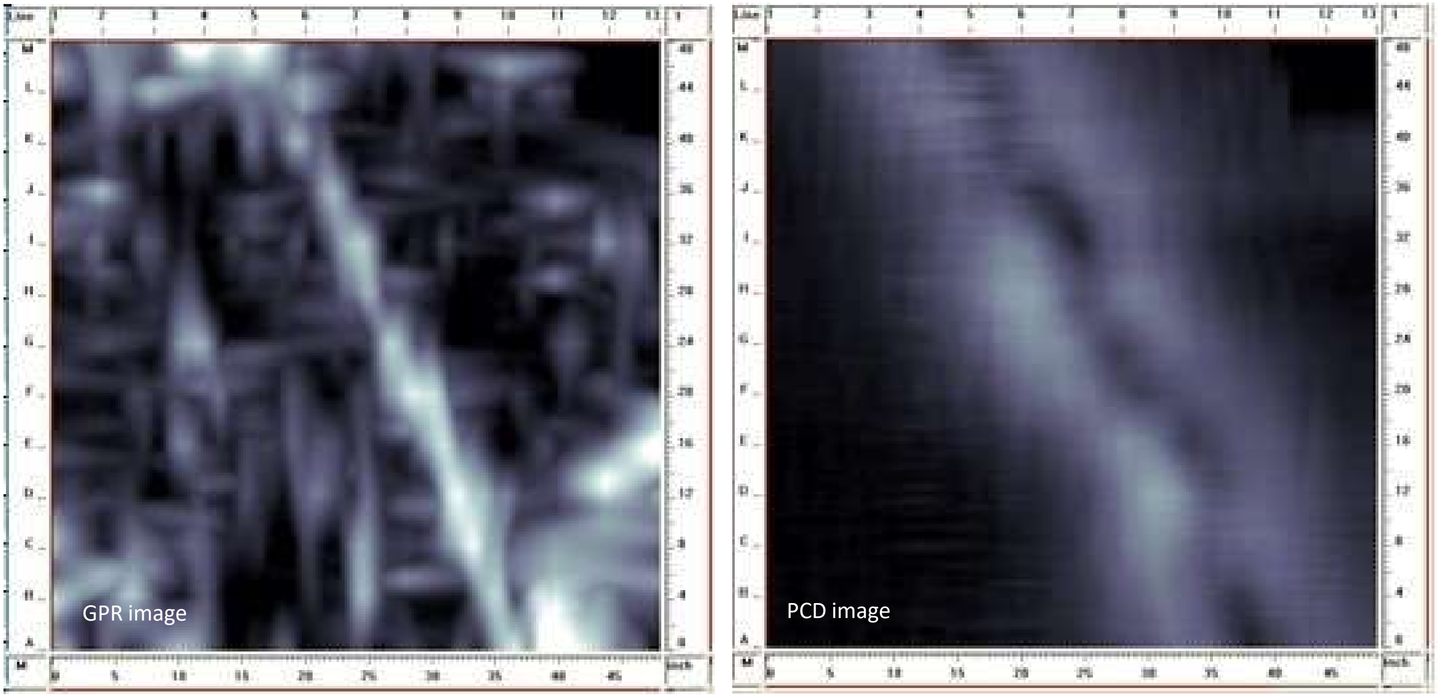
The PCD data is not so obvious, but illustrates how PCD can help determine which response is the conduit; the rebar and conduit appear to overlap.





These images show a few targets on the GPR image but only a faint haze on the PCD. This haze could potentially line up with a few targets. In order to resolve this problem, scan a larger area if possible or another grid nearby. If not, mark out any of grids as potential PCD targets

In the following examples, the diagonal object in the GPR data (left) has flowing current as shown in the PCD image (right). However, a black (null) area appears in the middle of the two white lines. This does not mean there are two targets; it is still one target. The reason two white lines are displayed is because there are two wires side-by-side in the conduit. Each wire is generating its own field and is canceling out in the middle (see GPR Theory – PCD).



The PCD data displays two white lines because there are two wires side-by-side in the conduit.

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We understand that the technology is only as useful as what it brings to your business or enterprise and our focus is in bringing value and competitive advantage.

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- Save time and money by targeting repair dollars intelligently

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